



# **The NASA In-Space Transportation Area**

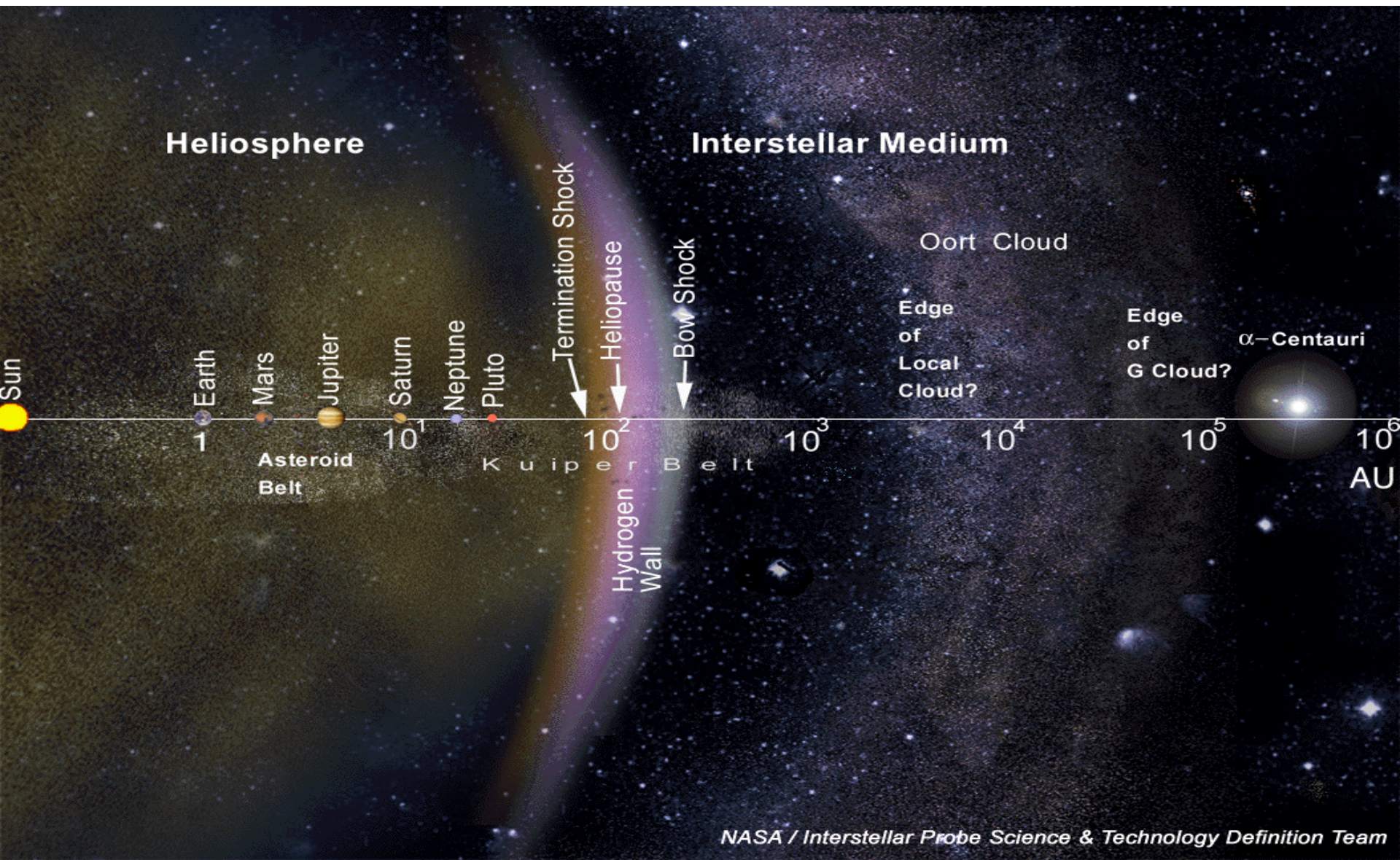
**Les Johnson**

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Advanced Space Transportation Program**

**NASA Marshall Space Flight Center  
Huntsville, AL**

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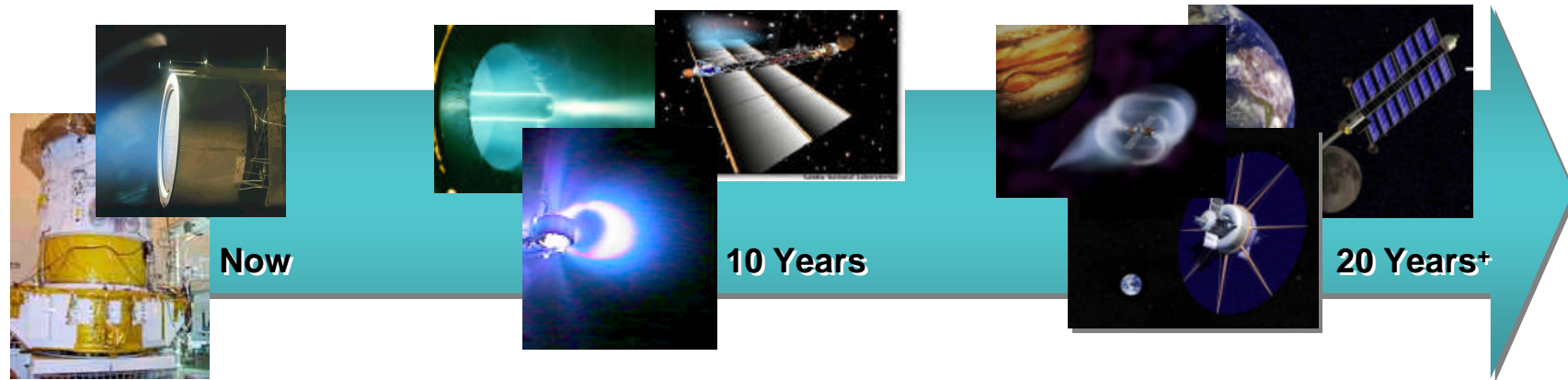
# In-Space Transportation Regime





# In-Space Transportation Technology Status and Goals

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**Now**

**10 Years**

**20 Years+**

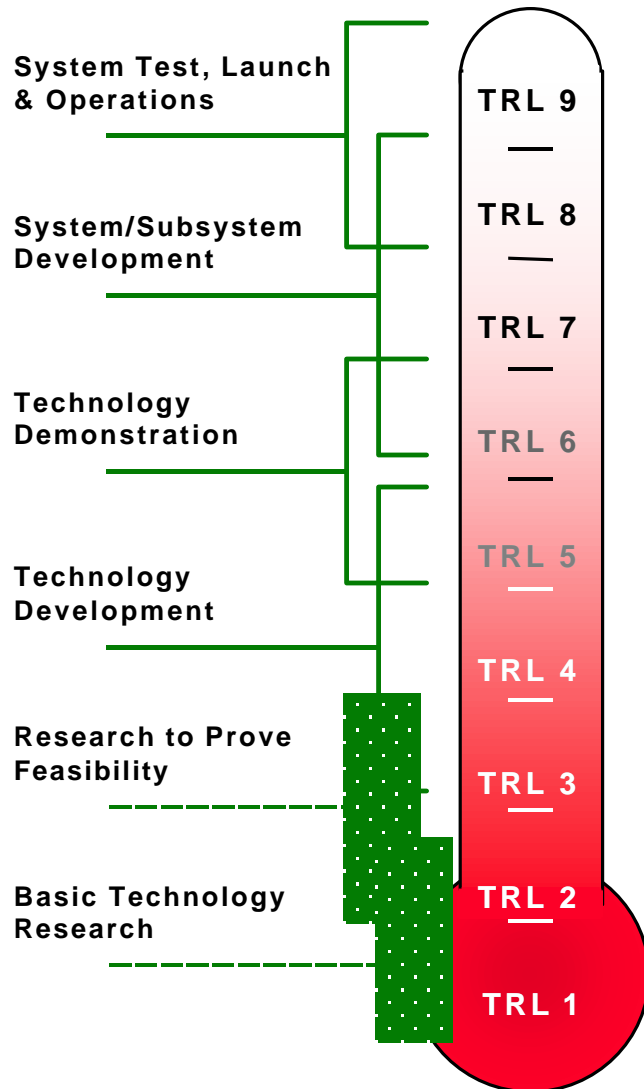
<b>Application Missions</b>	Upper Stages for LEO-to-GEO and robotic missions ; Humans to LEO.	Robotic missions anywhere in the solar system: Human mission capability for near-Earth space	Safe, low-cost human and robotic exploration of the solar system
<b>Metrics:</b>			
<b>Safety &amp; Reliability</b>	~1/200 failure probability	100X safer	10,000X safer
<b>Mass</b>	Chemical state-of-the-art	3X - 5X reduction	10X reduction
<b>Cost</b>	\$3000/kg LEO-to-GEO	\$1000/kg - \$300/kg	\$300 - \$100/kg

## Leading Candidate Technologies:

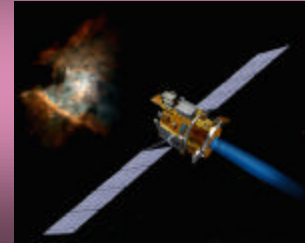
- ◆ High power electric propulsion (Isp: 3500 - 10,000 sec; power: 100 kW - 1 MW)
- ◆ Aeroassist and aerocapture (mid L/D aeroshells; ballutes)
- ◆ Plasma sails for efficient interplanetary transfer and inherent radiation protection
- ◆ Fission propulsion for rapid interplanetary transfer, planetary rendezvous and abundant in-situ power
- ◆ Momentum Transfer Tethers to provide a reusable in-space infrastructure for robotic and human exploration
- ◆ High energy density materials and advanced chemical fuels to increase Isp and reduce propulsion system mass

# In-Space Transportation Technology Focus

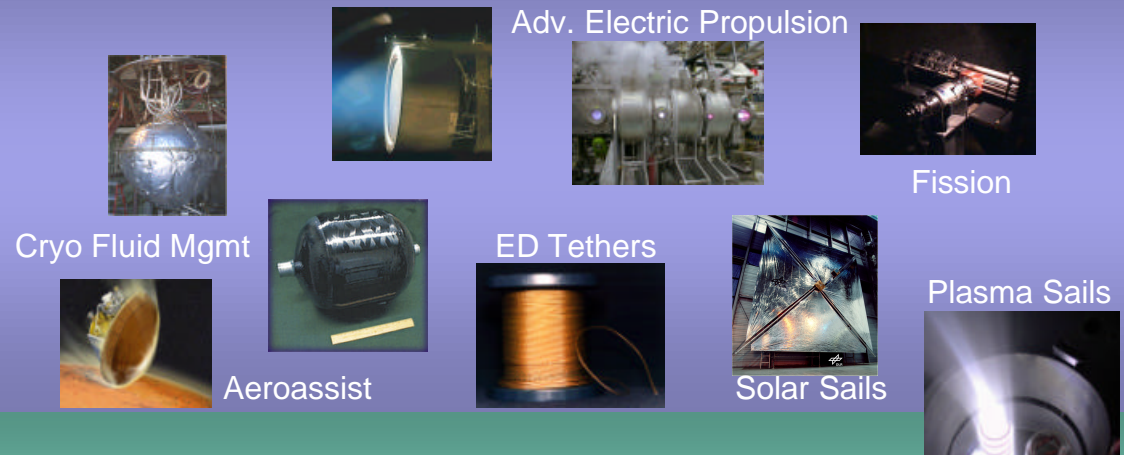
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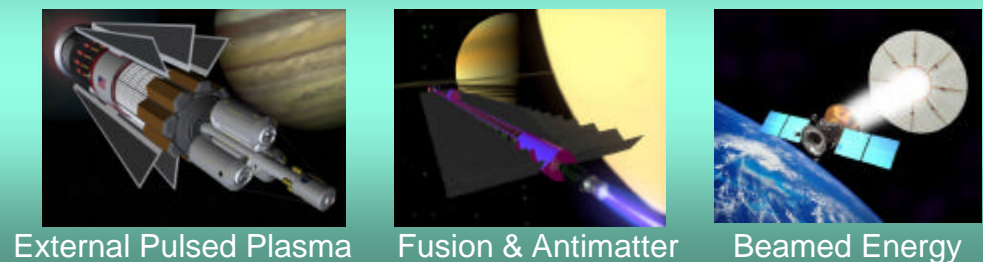
## NASA Implementation: (Deep Space One Ion Engine Example)



## ASTP: In-Space Transportation & Interstellar Precursor



## ASTP: Space Transportation Research



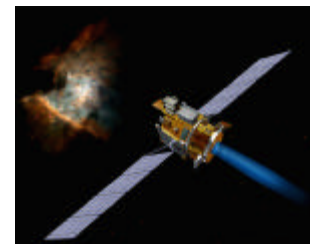


# Next Generation In-Space Transportation is Requirements Driven

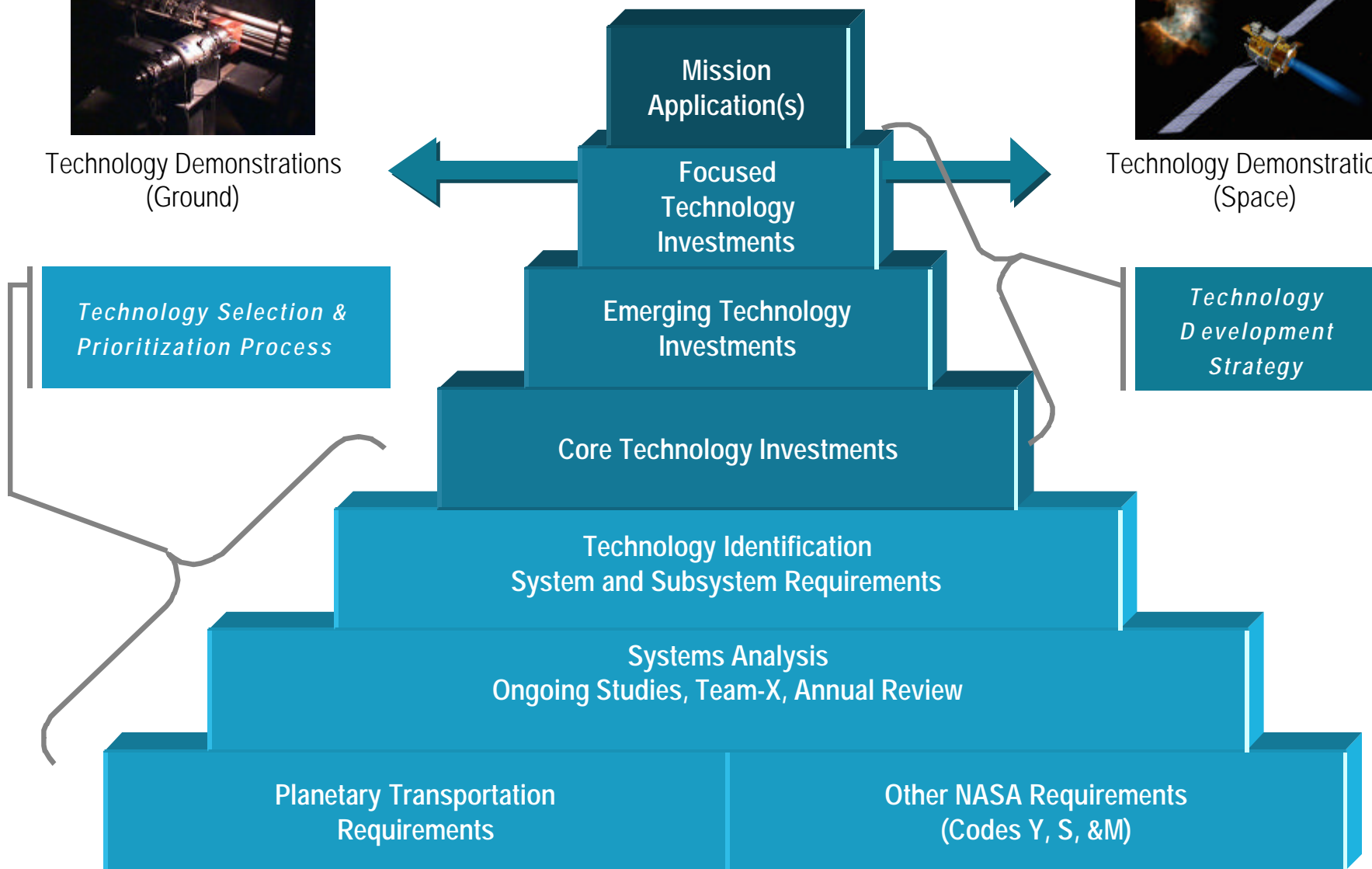
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Technology Demonstrations  
(Ground)



Technology Demonstrations  
(Space)





# Next Generation In-Space Transportation Technology

## *Development Areas*

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### ◆ Focused Technology Products

- Nearest-term technologies
- Emphasis on prototype systems
- Competitive procurement(s)

### ◆ Emerging Technologies

- Mid- to near-term technologies
- Emphasis on system and/or subsystems and key components
- Competitive procurement(s) and directed investments (eg., USG Labs)

### ◆ Core Technology Investments

- Supports near-, mid-, and far-term missions
- Supports agency-wide transportation requirements (Code S, Code M, Code Y)
- Emphasis on component technologies and proof of concept demonstrations
- Competitive procurement(s) and directed investments

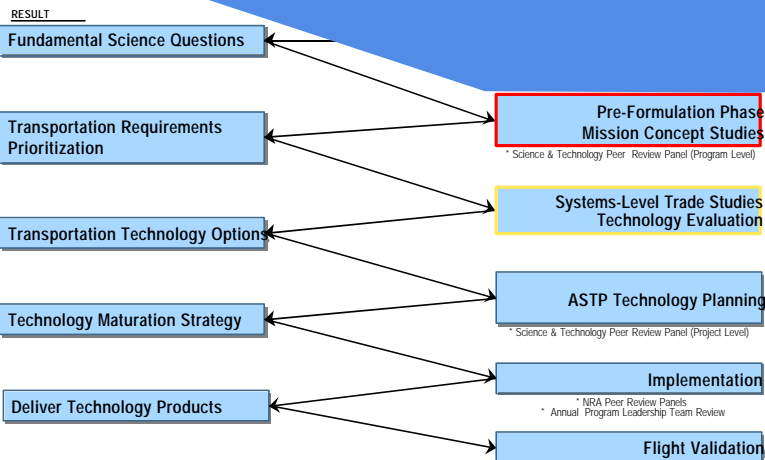
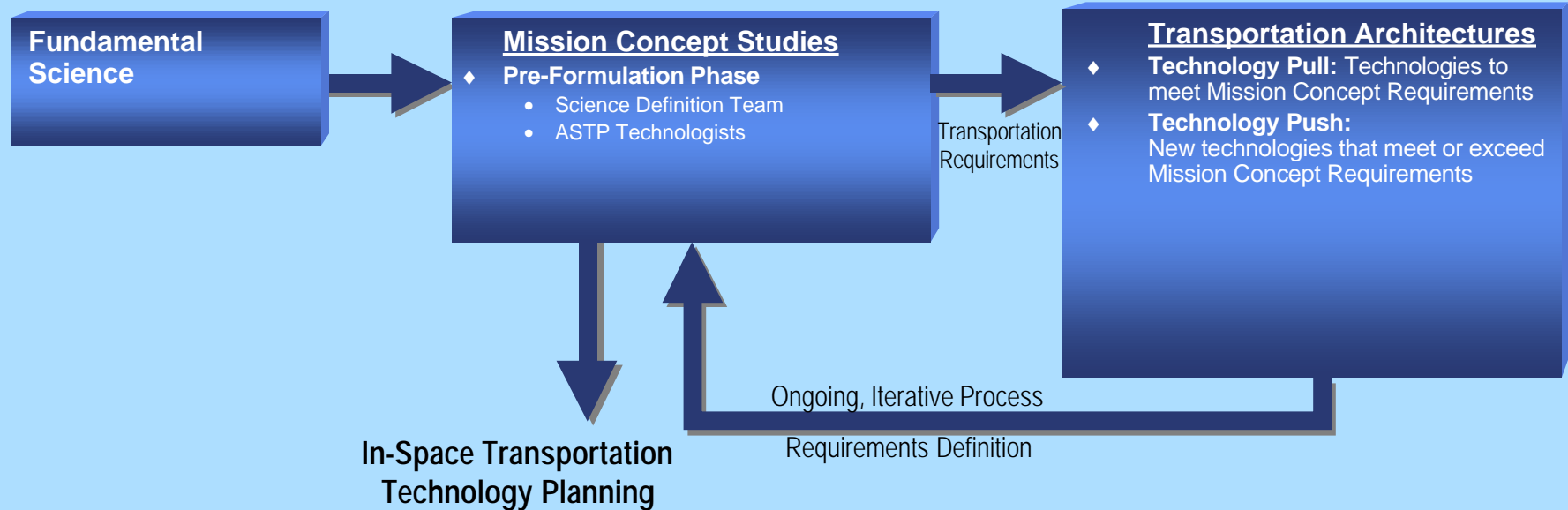
### ◆ Systems Analysis

- Supports near-, mid-, and far-term missions
- Ongoing definition and assessment of technologies and mission architectures
- NASA-lead with competitive procurements



# In-Space Transportation Systems Analysis Is A Partner to Advanced Mission Planning

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# Integrated, In-Space Transportation Planning (IISTP)

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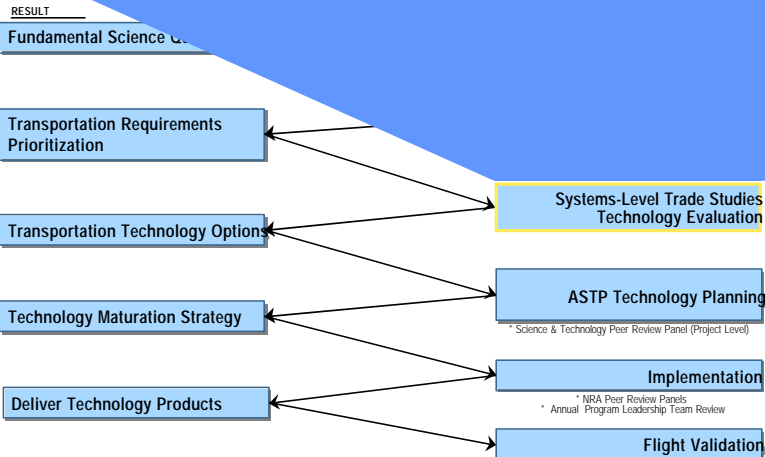
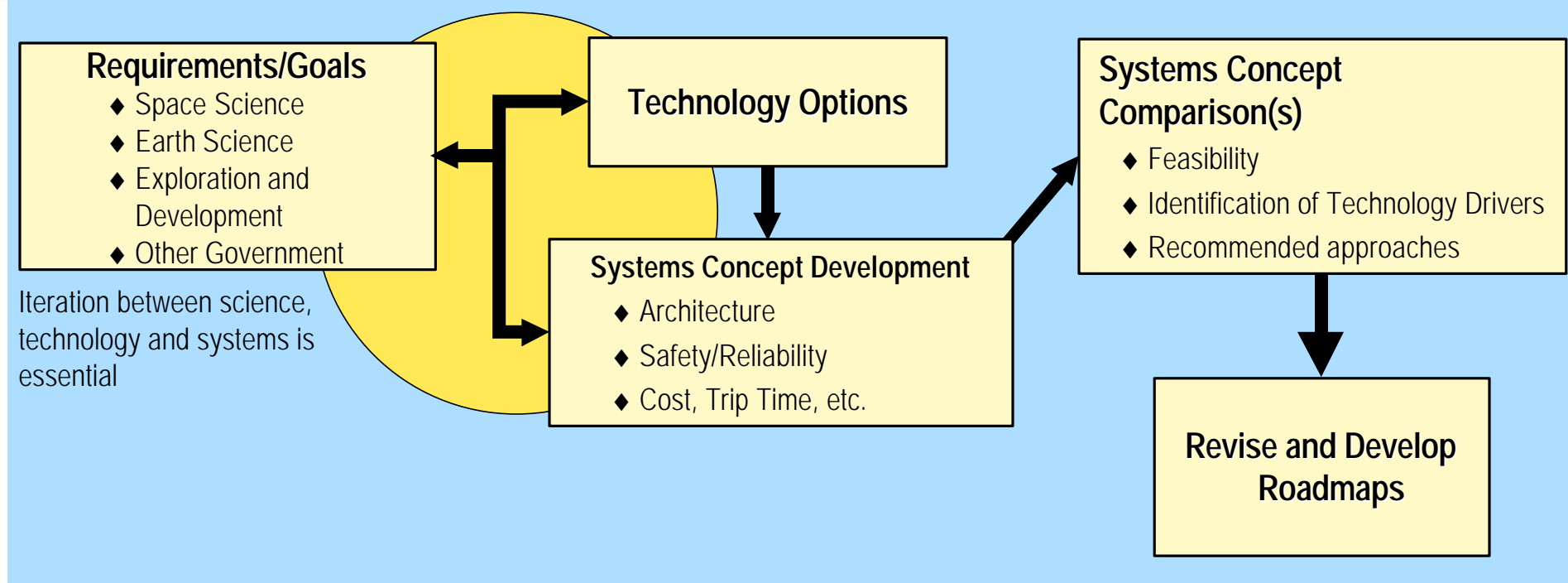
***IISTP is an annual process to:***

- ◆ **Develop baseline NASA requirements for In-Space Transportation**
  - Safety, Reliability, Cost, Mission Applications
- ◆ **Define Integrated Architectures (ongoing systems definition)**
  - NASA teams with industry, university and DoE participation
- ◆ **Identify and prioritize technology and advanced development drivers**
- ◆ **Develop and update an integrated Science and Exploration In-Space Transportation plan**
- ◆ **Assess current program content, metrics and funding priorities**



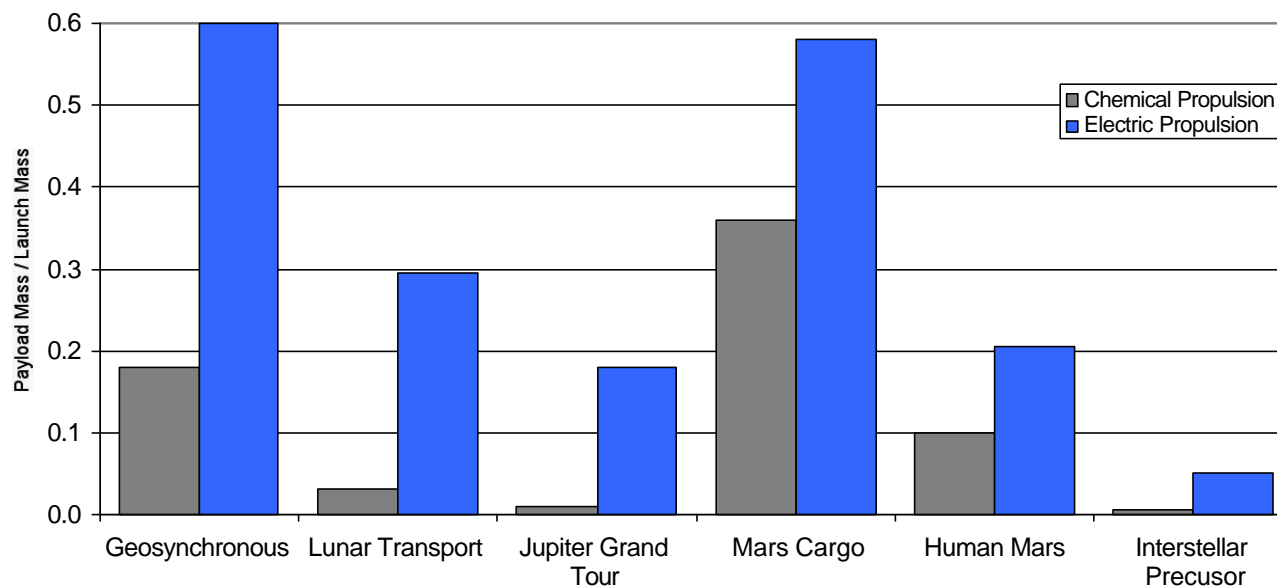
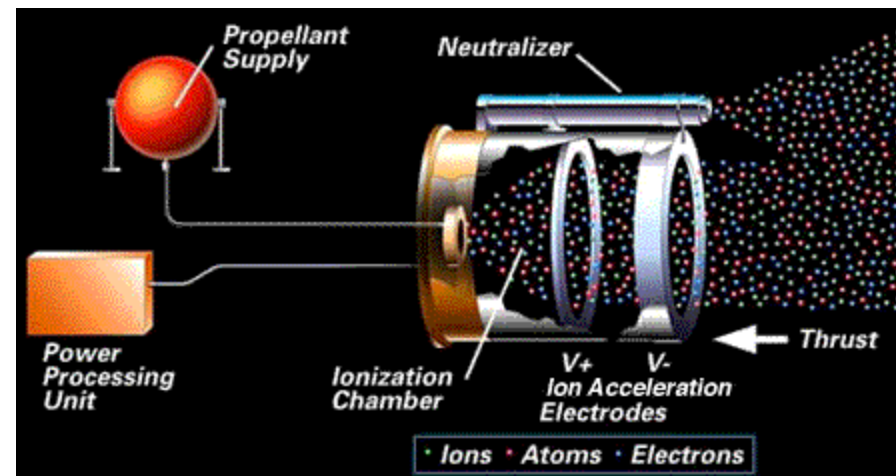
# Technology Evaluation Process Flow

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# Electric Propulsion

- ◆ High power electric and plasma thrusters provide reusable, quick access to near-Earth space and most of the solar system with 2 to 10 times the payload capability of chemical rockets



## NSTAR Engine:

30 centimeters

17.6 lbs (8 kg)

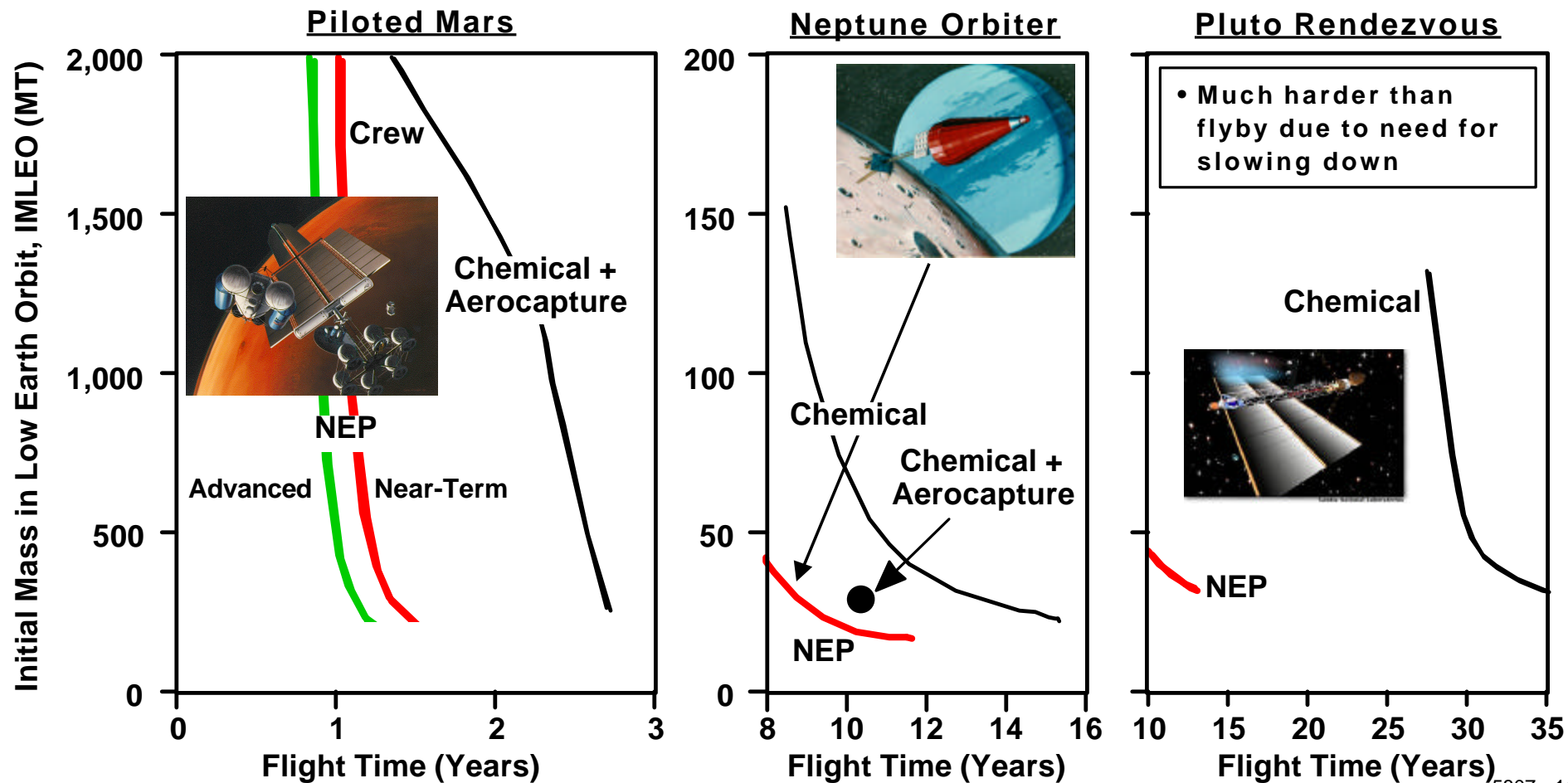
3100 seconds ISP

20 to 92 mN of thrust

# NEP Provides A New Capability for Science and Exploration

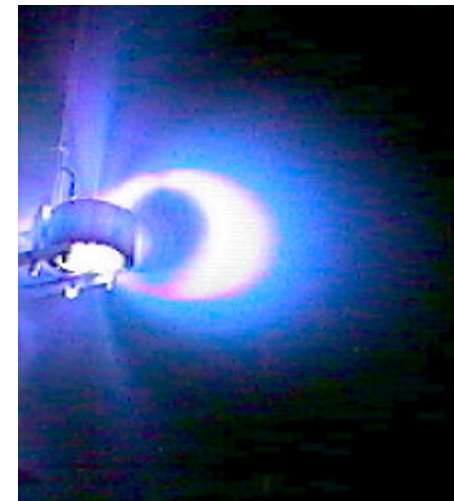
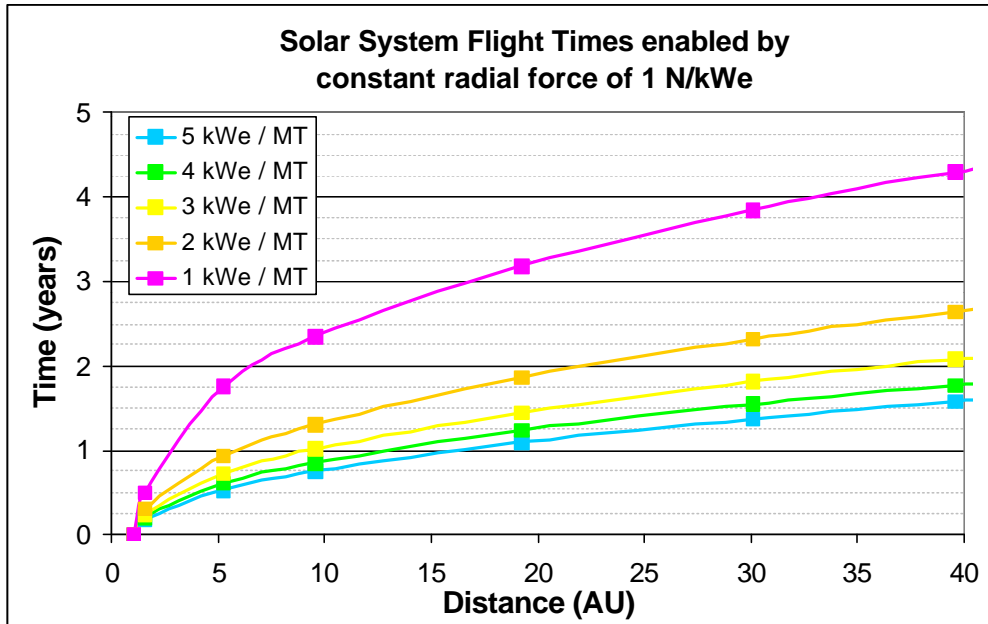
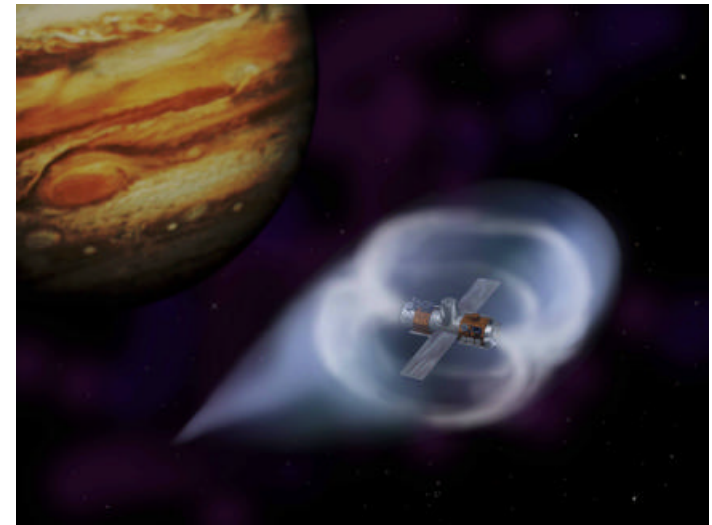
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- ◆ NEP can provide both IMLEO and trip time benefits for piloted and robotic missions
- ◆ Significant enhancements from advanced power and thruster technologies
- ◆ Can't use SEP or Solar Sails for orbit rendezvous missions significantly beyond Mars (no sunlight !)



# Plasma Sails

- ♦ 15km plasma sails riding the solar wind might carry robotic spacecraft to the outer solar system > 5 times faster than Voyager



**Plasma Sail Inflation Test**  
conducted by The University of  
Washington and NASA MSFC